DECON GREEN™

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Decon Green™ is a hydrogen peroxide-based decontaminant designed to replace DS2 and affords the broad-spectrum decontamination of chem/bio agents. Composed entirely of ingredients commonly found in cosmetics, detergents, laundry boosters and vitamins, Decon Green™ is extremely environmentally friendly and leaves no toxic residues. Decon Green™ retains the low temperature decontamination ability of DS2, but is non-corrosive to aluminum and steel. Decon Green™ is less harsh than DS2 on CARC-painted surfaces, yet provides a more thorough decontamination efficacy. The penetrating ability of Decon Green™'s excellent solvent system provides for the unsurpassed decontamination of both hard and soft surfaces. However, the latter may be compromised to minimize life-threatening off-gassing of sorbed agent from these non-hardened surfaces.

INTRODUCTION

Decon Green™[,1], an environmentally friendly decontaminant that has been under development for nearly a decade, is based on hydrogen peroxide – an environmentally friendly oxidant that leaves no toxic residues owing to its ready decomposition to water and oxygen in the environment. The development of Decon Green™ draws on the knowledge of many studies demonstrating the use of hydrogen peroxide to decontaminate chemical warfare agents; some nearly 50 years old. For example, early studies by Epstein et al.[2] and Larsson[3] showed that GB readily reacts with perhydroxyl ion (basic peroxide). Decades later, Yang et al.[4] reported that VX similarly undergoes rapid perhydrolysis, in a selective manner, to form non-toxic ethyl methylphosphonate (EMPA); thus avoiding formation of toxic EA-2192 (*S*-(2-diisopropylamino) ethyl methylphosphonothioate). Shortly thereafter, Drago et al.[5] found that hydrogen peroxide activated baking soda, forming its monoperoxocarbonate, was very effective for the selective oxidation of HD to its non-vesicant sulfone. At the conclusion of this latter study, it was recognized by Wagner and Yang[6] that hydrogen peroxide could be used to construct a decontamination solution effective for all three classes of chemical warfare agents: nerve agents G and V; and blister agent HD. The development of Decon Green™ then began in earnest.

Early formulations of Decon Green™ developed by Wagner et al.[7] utilized three simple components: baking soda, hydrogen peroxide and an alcohol co-solvent; the latter ingredient added mainly to dissolve water-insoluble HD. However, it soon became apparent that more basic solutions were required to effectively react with realistic quantities of VX, at which point the more basic carbonate, e.g. K_2CO_3, was utilized. Yet this decreased the effectiveness of such formulas for HD oxidation as the formation of the needed monoperoxocarbonate is curtailed at higher pH.[8] Wagner et al.[8] then began utilizing molybdate, e.g. K_2MoO_4, which forms the active oxidant tetraperoxomolybdate in the presence of hydrogen peroxide. Moreover, tetraperoxomolybdate is stable at basic pH and was found to be about two orders of magnitude more effective for selective HD oxidation than monoperoxocarbonate.[8] Therefore molybdate replaced

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **17 NOV 2004**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE **Decon Green**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Edgewood Chemical Biological Center Aberdeen Proving Ground, MD 21010**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001849, 2004 Scientific Conference on Chemical and Biological Defense Research. Held in Hunt Valley, Maryland on 15-17 November 2004 .

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**3**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

carbonate as the preferred oxidation catalyst for HD in Decon Green™.[9] It should be noted that molybdate is an essential mineral and is an ingredient in vitamins. Thus the inclusion of molybdate in Decon Green™ is in keeping with the environmentally friendly philosophy relied upon for the development of the decontaminant: "if you can eat it or put it on your skin, it is OK to use it as an ingredient in the decontaminant". At the same time molybdate was being examined, microemulsions were also developed[9,10] using solvents commonly found in cosmetics and surfactants routinely employed in agricultural spraying; again in keeping with the principle of selecting and employing only environmentally friendly ingredients.

In the current manuscript, data is reported for the decontamination of GD, VX, and HD on CARC painted surfaces to demonstrate the effectiveness of Decon Green™ for the decontamination of these chemical agents. Additional data is given for *Bacillus anthracis* and *Bacillus stearothermophilus* demonstrating that Decon Green™ is also effective against bio agents.

RESULTS AND DISCUSSION

Table 1 shows results for an initial formula, Decon Green™ "Classic", as compared to DS2. It can be seen that Decon Green™ Classic is either comparable to, or in most cases superior to DS2 for the decontamination of HD, THD (thickened HD), TGD (thickened GD), and VX. Table 2 gives results for the decontamination of *Bacillus anthracis* spores by Decon Green™ Classic and HTH. Thus besides being a superior chem decon, Decon Green™ Classic is also a superior bio decon.

TABLE 1. Decontamination of HD, THD, TGD, and VX on CARC-Painted Panels[a]
Decon Green™Classic vs. DS2

	HD		THD		TGD		VX	
Decon	Cont.	Resid.	Cont.	Resid.	Cont.	Resid.	Cont.	Resid.
Decon Green™ Classic	5.7	17.5	1.8	6.1	3.0	12.9	3.3	39.5
DS2	5.2	54.1	2.3	7.2	3.0	23.9	3.6	77.0

[a]Initial contamination level 10 g/m^2. Agent dwell time 1 hour. 15 min decontamination time. Contact hazard and residual agent expressed in $\mu g/cm^2$. Average of six replicates reported.

TABLE 2. Decontamination of *Bacillus anthracis*: Decon Green™ Classic vs. HTH[a]

Decon	Challenge	CFU[b] Recovered	Log Kill
Decon Green™ Classic	2.5×10^8	< 10 (no viable spores detected)	> 8-log
0.8 % HTH	2×10^7	3.2×10^6	< 1-log

[a]15 min decontamination time. [b]Colony-forming units.

Although Decon Green™ Classic performed quite well compared to DS2, it was desired to develop a new formula that would be less harsh on "soft" materials such as plastic, rubber and painted surfaces. This concern resulted in the development of New Decon Green™. Results for this decontaminant, compared to Decon Green™ Classic, are given in Table 3. It can be readily seen from these results that New Decon Green™, although less penetrating and therefore less harmful to soft materials, is not as effective as Decon

TABLE 3. Decontamination of HD, THD, TGD, and VX on CARC-Painted Panels[a]
New Decon Green™ vs. Decon Green™ Classic

	HD			THD			TGD			VX		
Decon	C1[b]	C2[c]	Res.	C1	C2	Res.	C1	C2	Res.	C1	C2	Res.
New Decon Green™	43.3	12.26	154.6	115.1	12.97	29.9	9.1	1.84	14.9	4.14	1.28	53.8
Decon Green™ Classic	17.2	3.56	57.0	16.38	2.65	91.3	5.2	1.66	13.3	1.46	0.37	47.2

[a]Initial contamination level 10 g/m^2. Agent dwell time 1 hour. 15 min decontamination time. Contact hazard and residual agent expressed in $\mu g/cm^2$. Average of six replicates reported.
[b]0 – 15 min contact hazard. [c]45 – 60 min contact hazard.

Green™ Classic for the decontamination of CARC painted surfaces. Table 4 shows decontamination results for *Bacillus stearothermophilus* spores, a species considered extremely resistant to peroxide sterilants. As seen for Decon Green™ Classic, New Decon Green™ retains excellent bio decon efficacy.

TABLE 4. Decontamination of *Bacillus stearothermophilus* by New Decon Green™

Challenge	CFU Recovered	Log Kill
1×10^5	No viable spores detected	≥ 5-log

[a]10 min decontamination time. [b]Colony-forming units.

The data obtained for both Decon Green™ Classic and New Decon Green™ show that viable peroxide-based decontaminants may be formulated which are superior to conventional, environmentally-harmful decontaminants. For soft materials such as plastics, rubber and painted surfaces, decontaminants which penetrate well provide the best and most thorough decontamination. However, such soft materials may be compromised by harsh decontaminants. This is perhaps a small price to pay when the health and welfare of personnel is considered.

CONCLUSION

Environmentally friendly, hydrogen peroxide-based decontaminants such as Decon Green™ may be formulated which are superior to conventional, environmentally harmful decontaminants. Moreover, these decontaminants simultaneously afford the rapid and effective decontamination of both chem and bio agents. However, penetrating formulas are needed to adequately decontaminate soft materials and these materials may be compromised during the decontamination process.

ACKNOWLEDGEMENTS

We thank the late Prof. Russell S. Drago and Prof. Clifford A. Bunton for many helpful discussions; Mr. Abraham L. Turetsky and Dr. Vipin K. Rastogi for performing the *Bacillus anthracis* work; and Dr. Dan Klein, STERIS Corp., for performing the *Bacillus stearothermophilus* study.

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